Conductivity of Aqueous K2CO3 up to 200 deg. C

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Conductivity of Aqueous K_2CO_3 up to 200 °C

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Electrolysis cells can be used for producing hydrogen and carbon monoxide (syngas) by electrolysis of water and carbon dioxide. Using suitable catalysts syngas can be reacted to form hydrocarbons i.e. synthetic fuels. Today's electrolysis cells based on oxide ion conductors (SOECs) cannot directly produce hydrocarbons due to the high operating temperature, 750-1000 °C, where the hydrocarbons are not stable [1]. A reduction in temperature to below 300 °C may make it possible to reduce water and carbon dioxide at the same time and form hydrocarbons directly in the cell. However, such a reduction in temperature will require new electrolyte and electrode materials. Furthermore, good electrocatalysts are needed in order to promote the desired reactions.

The electrolyte is a key part of an electrolysis cell, and it is essential to know its properties in order to design a cell properly. Some of the important properties are the ionic conductivity, the thermal expansion and the materials stability at elevated temperatures and in this case also elevated pressures. Aqueous electrolytes are known for their high conductivity at lower temperatures, but are more difficult to handle than solid electrolytes and water management is a big issue. However, pressurized and immobilized aqueous electrolytes, such as K_2CO_3 (aq), can be used above 100 °C and may be easier to handle.

The conductivity of pure K_2CO_3 (aq) and immobilized K_2CO_3 (aq) has been determined from 25 °C up to ~200 °C at 30 bar. Special corrosion resistant sample holders have been designed for measurements on both liquid and immobilized liquid. Initial measurements were performed using the van der Pauw method [2] and electrochemical impedance spectroscopy (EIS). A porous solid disc with a porosity of 50 vol% was used for the immobilization. Nitrogen was used for the pressurization. Figures 1 and 2 show the conductivity, measured using the van der Pauw method, of pure and immobilized K_2CO_3 (aq) at various concentrations and temperatures at 30 bar.

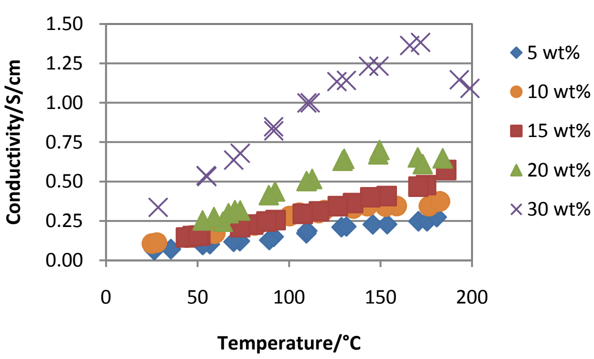

Figure 1. Conductivity of 5-30 wt% K_2CO_3 (aq) measured at 30 bar.

It was found that below 160 °C the conductivity increased with both temperature and concentration. For application at temperatures above 200 °C only concentrations below 20 wt% can be used due to precipitation. The highest conductivity measured was 1.4 S/cm at 180 °C for 30 wt% K_2CO_3 (aq) and 0.2 S/cm for 30 wt% immobilized K_2CO_3 (aq) at 131 °C.

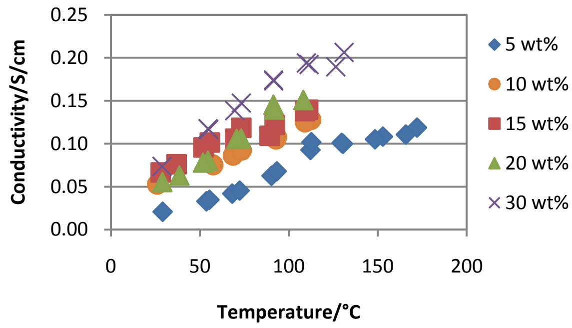

Figure 2. Conductivity of 5-30 wt% K_2CO_3 (aq) immobilized in a porous solid disc, measured at 30 bar.

A symmetrical cell with 10 wt% immobilized K_2CO_3 (aq) was tested in nitrogen and carbon dioxide, see figure 3. Again a specially designed corrosion resistant sample holder was used and the conductivity was measured using EIS. The setup was pressurized to 30 bar at room temperature, and the pressure was then allowed to increase with the temperature, resulting in a max pressure of 65 bar. The disc had a porosity of ~30 vol%.

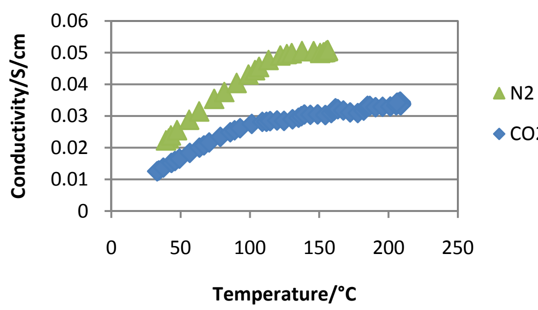

Figure 3. Conductivity of 10 wt% K_2CO_3 (aq) immobilized in a porous solid disc as a function of temperature. Initial pressure was 30 bar and the pressure was allowed to increase with the temperature.

The as-measured conductivity was found to be lower for the symmetrical cell than for the 10 wt% K_2CO_3 (aq) disc used for the van der Pauw method. This may be explained by the difference in porosity of the solid discs. A drop in conductivity was observed when the gas was changed from N_2 to CO_2 at room temperature. This may be due to precipitation of $KHCO_3$. Over the whole temperature range the conductivity was found to be lower in CO_2 than in N_2. In both gases the conductivity was found to be stable at the maximum temperature. In N_2 the temperature was kept constant at 156 °C for 3 hours and the conductivity was 0.0507±0.0002 S/cm. In CO_2 the temperature was kept constant at 209 °C for 11 hours and the conductivity was 0.0340±0.001 S/cm.

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References

1. S. D. Ebbesen and M. Mogensen, *J. Power Sources*, **193** 349 (2009)
2. L. J. van der Pauw, *Philips Res. Repts*, **13** 1 (1958)